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(54) **SYSTEM AND METHOD FOR HIGHLY ACCURATE REAL TIME TRACKING AND LOCATION IN THREE DIMENSIONS**

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(52) **U.S. Cl.** **342/357.07**; 342/357.06; 701/213
(58) **Field of Search** 342/352, 357.01, 342/357.06, 357.07, 357.12; 701/207, 213, 215

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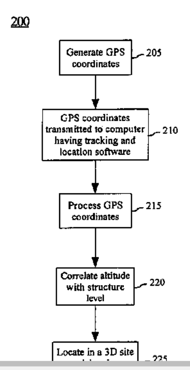
(57) **ABSTRACT**

A method and system for tracking an object by generating GPS coordinates for the object and a bearing associated with a movement of the object. The GPS coordinates include a latitude, a longitude, and an altitude, which are processed. The GPS coordinates can be processed to correlate the altitude of the object with an identifier that identifies a level within a structure. An icon representing the object then can be accurately located in a first view of a three dimensional model. An indicator can be associated with the icon to indicate the object's level, a bearing of the object, and/or the object's GPS coordinates. The object's GPS coordinates can be compared with a second object location to determine dispatch instructions. The object can be a person, a vehicle, watercraft or an aircraft.

19 Claims, 2 Drawing Sheets



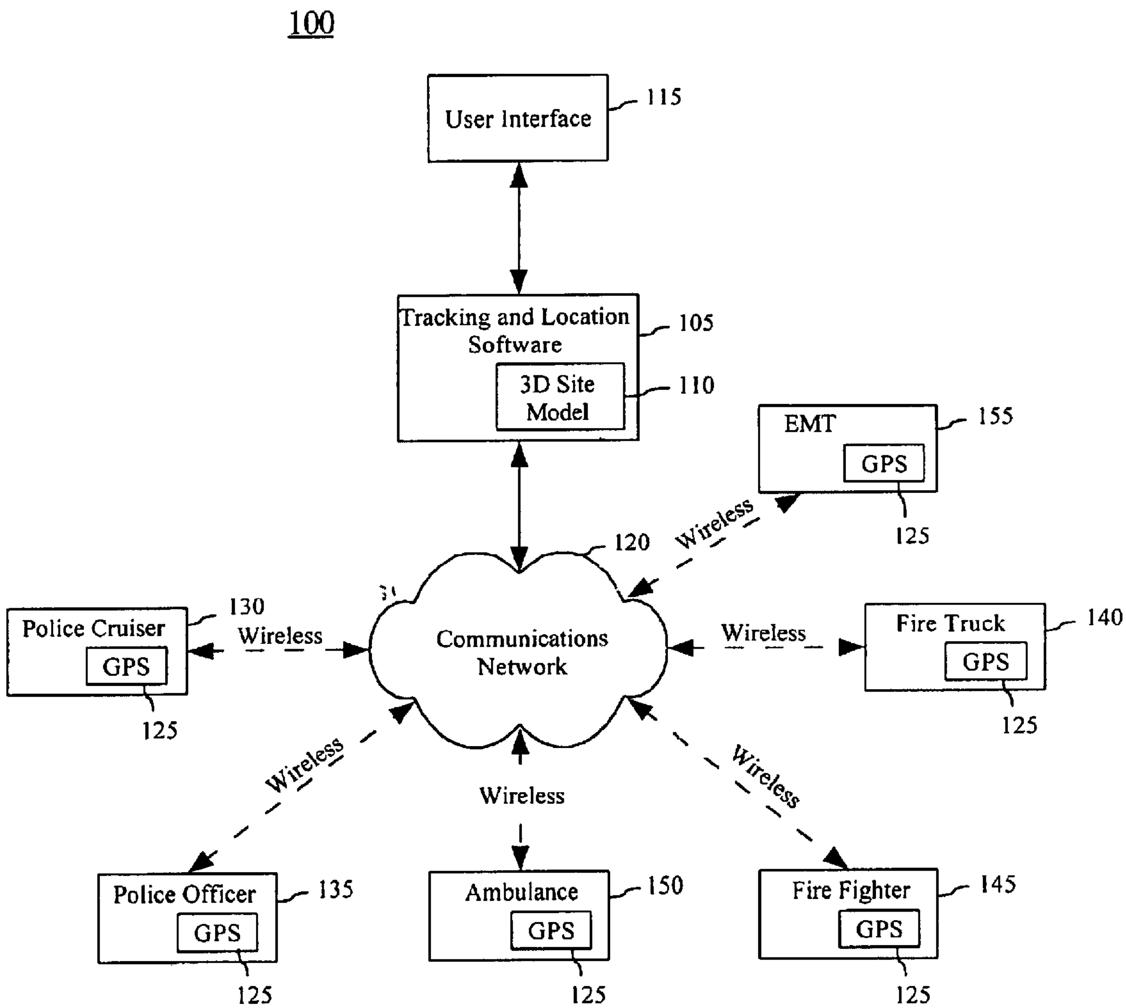

100
User Interface
115
Tracking and Location Software
105
3D Site Model
110
EMT
GPS
155
125
120
Wireless
Communications Network
Police Cruiser
GPS
130
Wireless
125
Wireless
Fire Truck
GPS
140
125
Wireless
Wireless
Wireless
Police Officer
GPS
135
125
Ambulance
GPS
150
125
Fire Fighter
GPS
145
125

Fig. 1

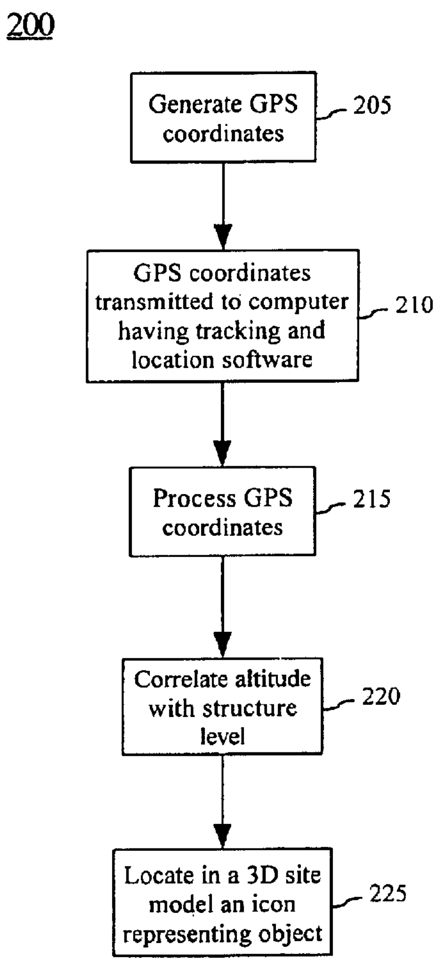

200
Generate GPS coordinates
205
GPS coordinates transmitted to computer having tracking and location software
210
Process GPS coordinates
215
Correlate altitude with structure level
220
Locate in a 3D site model an icon representing object
225

Fig. 2

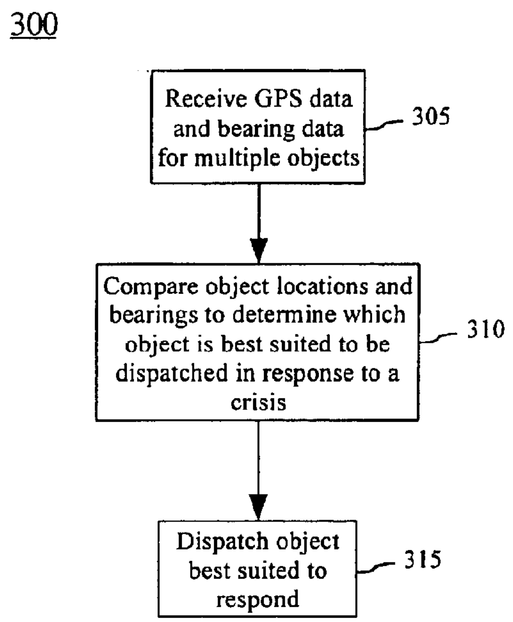

300
Receive GPS data and bearing data for multiple objects
305
Compare object locations and bearings to determine which object is best suited to be dispatched in response to a crisis
310
Dispatch object best suited to respond
315

Fig. 3

SYSTEM AND METHOD FOR HIGHLY ACCURATE REAL TIME TRACKING AND LOCATION IN THREE DIMENSIONS

BACKGROUND OF THE INVENTION

1. Statement of the Technical Field

The present invention relates to the field of geographic information systems (GIS) technology, and more particularly to a representation of an object being tracked in a three-dimensional geographic model.

2. Description of the Related Art

Computer-based object tracking systems have become available to provide object location and tracking information. For example, Automatic Vehicle Location (AVL) systems are available that utilize a Global Positioning System (GPS) to obtain data that can be used to monitor a vehicle location. The vehicle location data can be presented to a user at a monitoring station, typically via a computer interface. The user can monitor the vehicle location from the monitoring station.

In addition to a monitoring station, a typical AVL system commonly includes mobile units, a wireless communication network, and a computer system incorporating geographic information systems (GIS) technology. A mobile unit is a device that can be installed in a vehicle to enable the vehicle to be monitored and tracked, and typically includes a GPS receiver and a wireless transmitter. The mobile unit receives positioning signals from GPS satellites in the form of code sequences and converts these code sequences to pseudo range information or standard GPS code (NMEA). Pseudo ranges from a minimum of four different satellites are required in most instances for position calculation. These pseudo ranges or NMEA codes are subsequently transmitted via the wireless network to the monitoring station for position calculation.

The computer system incorporating GIS technology is usually equipped and configured to process GPS data and to monitor vehicle locations. The computer system performs filtering of the pseudo range signals or raw GPS data transmitted from the mobile units and further reduces these ranges into map coordinates for display. Current systems may also perform position corrections by using differential continuous positioning system (CPS) data obtained from a station in the vicinity of the vehicle being monitored.

Most conventional systems using GIS technology process GPS data according to two-dimensional (2D) spatial references. Still, conventional GIS technologies can be configured to process topographic data, in addition to rudimentary 2D data, usually in the form of a digital elevation model. Based upon the topographic data, isometric views and contour maps can be generated. Tracking system users, however, have recognized the limitations of a 2D modeling paradigm for modeling three-dimensional (3D) phenomena, even when combined with topographic data.

Notably, some GIS technologies can integrate scene generation systems for the 3D visualization of data, but the elevation coordinate data in these systems has been included only to "drape" a two-dimensional mapping over topographic data to produce what is known as a 2.5D model. Importantly, the use of a 2.5D model ought not to be confused with 3D. The elevation information in a 2.5D model is limited to the pre-determined elevation data for a geographic surface, such a road. Accordingly, application of

Notably, in a 2.5D, one elevation is typically assigned for an entire structure. Hence, floors in multilevel structures, such as high rise office buildings and apartment buildings, cannot be accurately represented in a 2.5D model. Accordingly, the current tracking technology does not provide a means for tracking personnel, for example fire fighters, as the personnel travel between floors in a multilevel structure. Further, current tracking technology cannot provide accurate 3D images from various perspectives within a scene, for example, the view of a bank from the perspective of a police officer positioned on the roof of a building located across the street from the bank.

SUMMARY OF THE INVENTION

The present invention relates to a method and a system for tracking and locating objects and representing those objects as icons within a highly accurate three-dimensional (3D) model. The present invention tracks an object, such as a person, a vehicle, or an aircraft, by generating GPS coordinates for the object and a bearing associated with a movement of the object. In particular, the GPS coordinates include a latitude, a longitude, and an altitude. Importantly, the GPS coordinates can be processed to correlate the altitude of the object with an identifier that identifies a level within a structure. An icon representing the object then can be accurately located in a first view of a three dimensional model. Further, an indicator can be associated with the icon to indicate the object's level, a bearing of the object, and/or the object's GPS coordinates.

The GPS coordinates of the object also can be compared with a location of a second object to generate a comparison. The comparison can be processed to determine the content of a communication that is transmitted to the object, for example a dispatch message. The communication can be transmitted wirelessly to the object and can be encrypted prior to being transmitted. The object can be a person, a vehicle, a watercraft or an aircraft. Lastly, biological statistics, mechanical statistics, fuel level, speed, velocity and other parameters of the object can be monitored.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a system for tracking and locating objects within a highly accurate three dimensional model in accordance with the present invention.

FIG. **2** is a flow chart for tracking and locating objects within a highly accurate three dimensional model in accordance with the present invention.

FIG. **3** is a flow chart for providing dynamically adjusted computer aided dispatch based on object location in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to a method and a system for tracking and locating objects and representing those objects as icons within a highly accurate three-dimensional (3D) model. Importantly, the movements of various objects throughout an area can be monitored. For example, the locations and movements of police cruisers, helicopters, rescue vehicles, and personnel can be continually monitored throughout a city. More importantly, resources, such as personnel, can be accurately tracked when traveling through a city and, in particular, within multilevel structures. For during a structure fire. Further, police officers can be tracked as they give vehicle or foot chase to a criminal, for example in a multilevel parking garage.

In another arrangement of the present invention, accurate 3D images from the perspective of an object being tracked can be presented to a user. During a bank robbery, for example, a supervisor can view the bank from perspective of a police officer positioned on a roof near the bank. The perspective of other police officers at different positions around the bank also can be presented to the supervisor for improved situational awareness. Accordingly, supervisors and dispatchers are provided detailed information of a particular scenario which can be used to better evaluate existing circumstances, thereby leading to a better decision making process and improved resource allocations, both of which improve public service.

Referring to FIG. **1**, a block diagram **100** of a system for tracking and locating objects within a highly accurate three dimensional model is shown. The system includes tracking and location (T & L) software **105**, 3D mapping software (3D site model) **110**, and a user interface **115**. Further, each object being tracked can include a global positioning satellite (GPS) receiver **125**. For example, there can be a GPS receiver **125** in a police cruiser **130**, on a police officer **135**, in a fire truck **140**, on a fire fighter **145**, in an ambulance **150**, or on an emergency medical technician **155**. Still, many other objects can carry a GPS receiver **125** to enable object tracking of manned and unmanned objects. Other examples include trains, aircraft (helicopters, fixed wing, etc.), watercraft and so on.

Each GPS receiver can be connected to a transmitter to transmit GPS coordinates to the T & L software **105** using the communications network **120**. For example, in the case where a GPS receiver is in a vehicle, the GPS receiver can connect to existing RF transmission equipment, such as a police radio. If a GPS receiver is being carried on a person, however, the GPS receiver can include a transmitter. In another arrangement, a GPS receiver can integrate with a cell phone or a mobile radio. Or it can integrate with other communications devices including those operating on radio frequencies or optical wavelengths.

The T & L software **105** can receive an object's latitude, longitude and altitude coordinates, and bearing data from a GPS receiver associated with the object. The T & L software **105** then can place an icon representing the object into a 3D site model **110** that is presented to a user through the user interface **115**, for example on a video monitor. Importantly, an indicator can be presented in the icon or associated with the icon to indicate the bearing of the object. For example, a velocity of the object can be presented, indicating both the speed at which an object is moving and the direction the object is moving in. In particular, an arrow can be presented with the icon to indicate a direction the object is moving. The direction also can be presented numerically or graphically. For example, degrees can be indicated numerically or with a compass style indicator. The speed at which the object is moving also can be presented numerically or graphically. For example, speed can be indicated numerically or with an icon that represents a speedometer display. An indicator also can be associated with the icon to indicate the GPS coordinates of the object.

The 3D site model **110** can be an accurate model of an area incorporating geographic features and structures. For example, the 3D site model **110** can be a model of a city,

For example, source imagery can be used to generate polygons representing features and structures to be shown in the 3D site model **110**. Notably, the source imagery can be any form of feature identification, for example information generated by aerial and satellite photography, electro-optical imaging, infrared detection, synthetic aperture radar (SAR), hyperspectral imaging, light detection and ranging (LIDAR), and even handheld photographs. The model resulting from the polygons then can be shaded and textured to provide a photo-realistic and accurate representation of the area.

A database can be associated with the 3D site model and structures in the 3D site model **110** can be assigned attributes. For example, the composition of structures can be identified. Special features and comments related to a structure also can be noted, for example, whether a structure has a basement, the age of a structure, whether a structure has a fire escape and/or sprinkler system, and so on. In one arrangement, the internal layout of particular structures can be incorporated in the 3D site model **110**, for example, the elevation (altitude) of each floor and the location of stair wells and elevators within the structure. Moreover, the database can be structured in a manner wherein the attributes associated with each building are organized by floor or altitude.

The T & L software **105** can be stored on a data storage device, such as a data storage associated with a computer system. For example, the T & L software **105** can be stored on a magnetic storage medium, an optical storage medium, a magneto-optical medium, etc. The T & L software **105** can be executed on a computer or any other device incorporating a processor capable of processing 3D graphical information. For example the T & L software **105** can be executed on a server, a workstation, a personal computer, a laptop computer, a mobile computer, a hand held computer, a body worn computer, etc.

As previously noted, a communications network **120** can be used by a GPS **125** to communicate GPS data to the T & L software **105**. The communications network can include the Internet, a wide area network (WAN), a local area network (LAN), a mobile communications network, a public switched telephone network, or any other network capable of transmitting GPS data. For example, the GPS receivers **125** can communicate via a wireless network, such as a cellular communications network or an IEEE 802.11 network. Importantly, the communications network **120** can include a myriad of systems capable of transmitting GPS data.

A user, for example a supervisor or a dispatcher, can use the user interface **115** to interact with the T & L software **105**. For example, the user interface can comprise a display, a keyboard, and a mouse. However, the user interface is not limited to these devices. For example, the user interface can include a projector, a joystick, speech recognition hardware and software, speakers, and any other device a user can use to interact with a software package.

FIG. **2** is a flow chart **200** for tracking and locating an object within a highly accurate three dimensional model. Referring to step **205**, GPS data for the object can be generated by a GPS receiver **125** and transmitted to the T & L software **105**, as previously noted. For example, the GPS data can be transmitted to a computer having the tracking and location software, as shown in step **210**. For example, the GPS data can be wirelessly transmitted from the GPS receiver to a basestation, which can wireline transmit the

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